CLAIMS

What is claimed is:

1. A laminar, thermally-conductive interface interposable intermediate a first heat transfer surface and an opposing second heat transfer surface to provide a thermally-conductive pathway therebetween, said interface having a having a first interface surface disposable in heat transfer contact with the first heat transfer surface and an opposing second interface surface disposable in heat transfer contact with the second heat transfer surface, said interface comprising:

a first layer formed of a flexible, lamellar graphite material, said first layer having a first interior surface and a first exterior surface defining said first interface surface of said interface; and

a second layer formed of a thermally-conductive phase-change material, said second layer having a second interior surface joined to the first interior surface of said first layer and a second interface surface defining said second interface surface of said interface.

2. The interface of claim 1 wherein said phase-change material is form-stable at normal room temperature in a first phase and conformable to the second interface surface in a second phase, said phase-change material having a transition temperature above normal room temperature from said first phase to said second phase.

3. The interface of claim 2 wherein:

the first heat transfer surface is located on a heat-generating source having an operating temperature range above normal room temperature; and

said transition temperature of said phase-change material is within the operating temperature said heat-generating source.

4. The interface of claim 2 wherein said transition temperature of said phase-change material is between about 40-80°C.

5. The interface of claim 3 wherein:

said heat-generating source is an electronic component; and

the second heat transfer surface is located on a thermal dissipation member.

6. The interface of claim 5 wherein the thermal dissipation member is a heat sink or a circuit board.

7. The interface of claim 1 wherein:

the first interface surface of said interface is substantially cleanly releasable from heat transfer contact with the first heat transfer surface; and

the second interface surface of said interface is bondable to the second heat transfer surface.

8. The interface of claim 7 wherein said phase-change material of said second layer is inherently tacky such that the second exterior surface thereof is adherable by said phase-change material to the second heat transfer surface.

9. The interface of claim 1 wherein said phase-change material comprises an admixture of a polymeric component and one or more thermally-conductive fillers.

10. The interface of claim 9 wherein said polymeric component comprises one or more resins, one or more waxes, or a blend of one or more waxes and one or more resins.

11. The interface of claim 10 wherein said resins or waxes are selected from the group consisting of thermoplastics, pressure sensitive adhesives, paraffinic waxes, and blends thereof.

12. The interface of claim 9 wherein said one or more thermally-conductive fillers is selected from the group consisting of boron nitride, titanium diboride, aluminum nitride, silicon carbide, graphite, metals, metal oxides, and mixtures thereof.

13. The interface of claim 9 wherein said phase-change material comprises between about 20-80% by weight of said one or more thermally-conductive fillers.

14. The interface of claim 9 wherein said phase-change material has a thermal conductivity of between about 0.1-5.0 W/m-K.

15. The interface of claim 1 wherein said first layer has a thickness of between about 2-20 mils (50-500 μm), and said second layer has a thickness of between about 2-20 mils (50-500 μm).

16. The interface of claim 1 wherein said graphite material comprises intercalated graphite flake which is formed into a sheet.

17. The interface of claim 1 wherein said interface has a thermal impedance of less than about 1 °C-in^2/W (6 °C-cm^2/W).

18. The interface of claim 1 wherein said first layer has a thermal impedance of between about 0.03-0.15 °C-in^2/W (0.18-0.9 °C-cm^2/W).

19. The interface of claim 1 wherein said second layer has a thermal impedance of less than about 0.2 °C-in^2/W (1.2 °C-cm^2/W).

20. A thermal management assembly comprising:

a first heat transfer surface;

a second heat transfer surface opposing said first heat transfer surface; and

a laminar, thermally-conductive interface interposed intermediate said first and said second heat transfer surface to provide a thermally-conductive pathway therebetween, said interface having a having a first interface surface disposed in heat transfer contact with said first heat transfer surface and an opposing second interface surface disposed in heat transfer contact with said second heat transfer surface, said interface comprising:

a first layer formed of a flexible, lamellar graphite material, said first layer having a first interior surface and a first exterior surface defining said first interface surface of said interface; and

a second layer formed of a thermally-conductive phase-change material, said second layer having a second interior surface joined to the first interior surface of said first layer and a second interface surface defining said second interface surface of said interface.

21. The assembly of claim 20 wherein said phase-change material is form-stable at normal room temperature in a first phase and conformable to the second interface surface in a second phase, said phase-change material having a transition temperature above normal room temperature from said first phase to said second phase.

22. The assembly of claim 21 wherein:

said first heat transfer surface is located on a heat-generating source having an operating temperature range above normal room temperature; and

said transition temperature of said phase-change material is within the operating temperature said heat-generating source.

23. The assembly of claim 21 wherein said transition temperature of said phase-change material is between about 40-80°C.

24. The assembly of claim 22 wherein:

said heat-generating source is an electronic component; and

said second heat transfer surface is located on a thermal dissipation member.

25. The assembly of claim 24 wherein said thermal dissipation member is a heat sink or a circuit board.

26. The assembly of claim 20 wherein:

said first interface surface of said interface is substantially cleanly releasable from heat transfer contact with said first heat transfer surface; and

said second interface surface of said interface is bondable to said second heat transfer surface.

27. The assembly of claim 26 wherein said phase-change material of said second layer is inherently tacky and adheres said second exterior surface thereof to said second heat transfer surface.

28. The assembly of claim 20 wherein said phase-change material comprises an admixture of a polymeric component and one or more thermally-conductive fillers.

29. The assembly of claim 28 wherein said polymeric component comprises one or more resins, one or more waxes, or a blend of one or more waxes and one or more resins.

30. The assembly of claim 29 wherein said resins or waxes are selected from the group consisting of thermoplastics, pressure sensitive adhesives, paraffinic waxes, and blends thereof.

31. The assembly of claim 28 wherein said one or more thermally-conductive fillers is selected from the group consisting of boron nitride, titanium diboride, aluminum nitride, silicon carbide, graphite, metals, metal oxides, and mixtures thereof.

32. The assembly of claim 28 wherein said phase-change material comprises between about 20-80% by weight of said one or more thermally-conductive fillers.

33. The assembly of claim 28 wherein said phase-change material has a thermal conductivity of between about 0.1-5 W/m-K.

34. The assembly of claim 20 wherein said first layer has a thickness of between about 2-20 mils (50-500 µm), and said second layer has a thickness of between about 2-20 mils (50-500 µm).

35. The assembly of claim 20 wherein said graphite material comprises intercalated graphite flake which is formed into a sheet.

36. The assembly of claim 20 wherein said interface has a thermal impedance of less than about 1 °C-in^2/W (6 °C-cm^2/W).

37. The assembly of claim 20 wherein said first layer has a thermal impedance of between about 0.03-0.15 °C-in^2/W (0.18-0.9 °C-cm^2/W).

38. The assembly of claim 20 wherein said second layer has a thermal impedance of less than about 0.2 °C-in^2/W (1.2 °C-cm^2/W).

39. A laminar, thermally-conductive interface interposable intermediate a first heat transfer surface and an opposing second heat transfer surface to provide a thermally-conductive pathway therebetween, said interface having a having a first interface surface

disposable in heat transfer contact with the first heat transfer surface and an opposing second interface surface disposable in heat transfer contact with the second heat transfer surface, said interface comprising:

a first layer formed of a flexible tin foil material, said first layer having a first interior surface and a first exterior surface defining said first interface surface of said interface; and

a second layer formed of a thermally-conductive phase-change material, said second layer having a second interior surface joined to the first interior surface of said first layer and a second interface surface defining said second interface surface of said interface.

40. The interface of claim 39 wherein said phase-change material is form-stable at normal room temperature in a first phase and conformable to the second interface surface in a second phase, said phase-change material having a transition temperature above normal room temperature from said first phase to said second phase.

41. The interface of claim 40 wherein:

the first heat transfer surface is located on a heat-generating source having an operating temperature range above normal room temperature; and

said transition temperature of said phase-change material is within the operating temperature said heat-generating source.

42. The interface of claim 40 wherein said transition temperature of said phase-change material is between about 40-80°C.

43. The interface of claim 41 wherein:

said heat-generating source is an electronic component; and

the second heat transfer surface is located on a thermal dissipation member.

44. The interface of claim 43 wherein the thermal dissipation member is a heat sink or a circuit board.

45. The interface of claim 39 wherein:

the first interface surface of said interface is substantially cleanly releasable from heat transfer contact with the first heat transfer surface; and

the second interface surface of said interface is bondable to the second heat transfer surface.

46. The interface of claim 45 wherein said phase-change material of said second layer is inherently tacky such that the second exterior surface thereof is adherable by said phase-change material to the second heat transfer surface.

47. The interface of claim 39 wherein said phase-change material comprises an admixture of a polymeric component and one or more thermally-conductive fillers.

48. The interface of claim 47 wherein said polymeric component comprises one or more resins, one or more waxes, or a blend of one or more waxes and one or more resins.

49. The interface of claim 48 wherein said resins or waxes are selected from the group consisting of thermoplastics, pressure sensitive adhesives, paraffinic waxes, and blends thereof.

50. The interface of claim 47 wherein said one or more thermally-conductive fillers is selected from the group consisting of boron nitride, titanium diboride, aluminum nitride, silicon carbide, graphite, metals, metal oxides, and mixtures thereof.

51. The interface of claim 47 wherein said phase-change material comprises between about 20-80% by weight of said one or more thermally-conductive fillers.

52. The interface of claim 47 wherein said phase-change material has a thermal conductivity of between about 0.1-5.0 W/m-K.

53. The interface of claim 39 wherein said first layer has a thickness of between about 1 mil (25 μm) or less, and said second layer has a thickness of between about 2-20 mils (50-500 μm).

54. The interface of claim 39 wherein said interface has a thermal impedance of less than about 1 °C-in^2/W (6 °C-cm^2/W).

55. The interface of claim 39 wherein said first layer has a thermal conductivity of about 60 W/m-K.

56. The interface of claim 39 wherein said second layer has a thermal impedance of less than about 0.2 °C-in^2/W (1.2 °C-cm^2/W).

57. A thermal management assembly comprising:

a first heat transfer surface;

a second heat transfer surface opposing said first heat transfer surface; and

a laminar, thermally-conductive interface interposed intermediate said first and said second heat transfer surface to provide a thermally-conductive pathway therebetween, said interface having a having a first interface surface disposed in heat transfer contact with said first heat transfer surface and an opposing second interface surface disposed in heat transfer contact with said second heat transfer surface, said interface comprising:

a first layer formed of a flexible tin foil material, said first layer having a first interior surface and a first exterior surface defining said first interface surface of said interface; and

a second layer formed of a thermally-conductive phase-change material, said second layer having a second interior surface joined to the first interior surface of said first layer and a second interface surface defining said second interface surface of said interface.

58. The assembly of claim 57 wherein said phase-change material is form-stable at normal room temperature in a first phase and conformable to the second interface surface in a second phase, said phase-change material having a transition temperature above normal room temperature from said first phase to said second phase.

59. The assembly of claim 58 wherein:

said first heat transfer surface is located on a heat-generating source having an operating temperature range above normal room temperature; and

said transition temperature of said phase-change material is within the operating temperature said heat-generating source.

60. The assembly of claim 58 wherein said transition temperature of said phase-change material is between about 40-80°C.

61. The assembly of claim 59 wherein:

said heat-generating source is an electronic component; and

said second heat transfer surface is located on a thermal dissipation member.

62. The assembly of claim 61 wherein said thermal dissipation member is a heat sink or a circuit board.

63. The assembly of claim 57 wherein:

said first interface surface of said interface is substantially cleanly releasable from heat transfer contact with said first heat transfer surface; and

said second interface surface of said interface is bondable to said second heat transfer surface.

64. The assembly of claim 63 wherein said phase-change material of said second layer is inherently tacky and adheres said second exterior surface thereof to said second heat transfer surface.

65. The assembly of claim 57 wherein said phase-change material comprises an admixture of a polymeric component and one or more thermally-conductive fillers.

66. The assembly of claim 65 wherein said polymeric component comprises one or more resins, one or more waxes, or a blend of one or more waxes and one or more resins.

67. The assembly of claim 66 wherein said resins or waxes are selected from the group consisting of thermoplastics, pressure sensitive adhesives, paraffinic waxes, and blends thereof.

68. The assembly of claim 65 wherein said one or more thermally-conductive fillers is selected from the group consisting of boron nitride, titanium diboride, aluminum nitride, silicon carbide, graphite, metals, metal oxides, and mixtures thereof.

69. The assembly of claim 65 wherein said phase-change material comprises between about 20-80% by weight of said one or more thermally-conductive fillers.

70. The assembly of claim 65 wherein said phase-change material has a thermal conductivity of between about 0.1-5 W/m-K.

71. The assembly of claim 57 wherein said first layer has a thickness of about 1 mil (25 μm) or less, and said second layer has a thickness of between about 2-20 mils (50-500 μm).

72. The assembly of claim 57 wherein said interface has a thermal impedance of less than about 1 °C-in^2/W (6 °C-cm^2/W).

73. The assembly of claim 57 wherein said first layer has a thermal conductivity of about 60 W/m-K.

74. The assembly of claim 57 wherein said second layer has a thermal impedance of less than about 0.2 °C-in^2/W (1.2 °C-cm^2/W).

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